THE BRITISH ASSOCIATION MEETING AT EDINBURGH

SECTION A.

OWING to the large number of papers still remaining in Section A, the Section was divided on Tuesday into two divisions.

Thermo-Electricity, by Prof. Tait. The principal object of this research was to verify certain deductions which the author had made from the principle of the Dissipation of Energy. But it had also a practical bearing, viz., to obtain a means of measuring high temperature, such as the melting point of iron or rocks. Sir W. Thomson's great investigation had pointed out for the first time that the whole subject of thermo-electricity depended on something more than the ordinary and well-known Peltiet effect; in fact, he predicted and subsequently verified by ingenious experiments the existence of what he called the specific heat of electricity, which, taken in conjunction with the Peltiet effect, supplied a complete explanation of the known phenomena consistent with the Conservation of Energy. His experiments further showed, if the relation between the electromotive force of a thermo-element and the temperature be represented by a curve in which the abscissæ are proportional to the temperature and the ordinates to the electromotive force, that this curve is symmetrical about an ordinate. But they did not show the form of the curve. Some preliminary experiments made by the author of the present paper had shown the curve to be so closely parabolic that he considered the subject worthy of a careful investigation. The difficulty of the research lay not so much in the experiments themselves as in obtaining wires of the infusible metals. He tried circuits of almost every metal which could be obtained in suitable wires, platinum, palladium, iron, &c., and on plotting the results, all the curves appeared to be parabolas. The form of experiment employed was this: As mercurial thermometers were inapplicable to temperatures above 300° C., the simultaneous indications of two separate thermo-electric circuits, the junction wires of which were immersed in the same hot and cold baths, were plotted one as abscissa the other as ordinate. This method gives a very delicate test of the parabolic law; for if the two curves obtained by plotting the two systems separately with the temperatures as abscissæ be exact parabolas, then the curve obtained as above will also be an exact parabola; but, if either of the former differ from the parabolic form, the latter will differ much more. All the results laid down by this method have as yet given very satisfactory approximations to parabolas. The consequences of this parabolic law are curious. If it be admitted, it proves the truth of the author's deduction from the principle of the dissipation of energy, viz., that Thomson's specific heat of electricity, like thermo and electric resistance, varies directly as the absolute temperature. The Peltiet effect is expressed as a parabolic function of the temperature. Another method of combining two thermo-electric circuits is to make the circuits, the junctions being in the same baths, act on a differential galvanometer in opposite directions. It is obvious, from the equations to the parabolas representing the relation of electromotive force to the temperature, or from considering the analogous case of the paths of two projectiles having the same horizontal velocity, and projected from the same point, that, by properly adjusting once for all temperatures the resistances of the two circuits, the term depending on the square of the temperature may be eliminated, and the galvanometer indication will be proportional to the difference of temperatures of the two baths.

Sir W. Thomson, speaking of the importance of Prof. Tait's research, pointed out that its results were in direct contradiction to the statements made in books on the subject.

A New Reflector for Lighthouses, by T. Stevenson.

The novelty of this lantern, which was a holophotal apparatus with a spherical and approximately paraboloidal mirror, combined with a Fresnel's lens, consisted in replacing the speculum which usually forms the mirror by plate-glass facets, silvered, like a looking-glass, at the back.

The paraboloidal mirror consisted of three annular facets formed by the revolution of a circular arc about a horizontal axis, the circular arc osculating the generating parabola to which it was required to approximate.

The facets were prepared at Messrs. Chance's works near Birmingham, by first bending plate glass into the approximate form, and then grinding and polishing the facets in the same way as the prisms of dioptric apparatus are ground and polished. The joints between the facets should be made good with Canada balsam; they can then be hardly seen, as the refractive index of the balsam is nearly the same as that of the glass.

It is sometimes necessary to construct a holophote which shall illumine a given arc of the horizon instead of the whole, as in the ordinary dioptric fixed light, or a very small portion alone, as in the revolving light; in fact, to send out a wedge-shaped beam diverging horizontally. This is usually effected by passing a portion of the light through a second system of prisms to deviate it into the required direction, after being rendered parallel in the usual way. But such a beam could be produced by a single reflection from a suitable surface, and, though it would be impossible to construct such a surface in speculum metal, facets of glass could be made osculating the surface, and be silvered at the back. Mr. Stevenson had asked Prof. Tait for formulæ to calculate the form of surface required.

Prof. Tait exhibited the formulæ he had obtained, and pointed out that such questions could be easily solved by quaternions, and that this calculus was peculiarly adapted to solve the problems of geometrical optics.

A Method of Estimating the Distance of Fixed Stars, by Mr. Fox Talbot.

The author did not know whether he had been anticipated in the proposal of the following method, and he left that to be determined by those better acquainted with practical astronomy.

The principle of the method may be seen from a simple example. Suppose the plane of the orbit of a binary system to pass through the sun, *i.e.* that the observer is in the plane of the orbit, and that in the spectra of the individual stars there are lines belonging to the same element. The spectra of the two stars taken through the same slit should be observed and compared. When the stars appear in the same straight line, it is clear that their velocities relative to the earth are the same, since both are moving perpendicularly to the line of vision; the lines from the two stars will therefore coincide. But when their apparent distance from each other is greatest, the difference of their velocities relative to the observer is equal to the velocity of either star in its orbit about the other. This difference of relative velocity will produce a displacement of the lines, which displacement may be observed and even measured. This will give us the value of that velocity. But we also know the periodic time. We have then at once the circumference and thence the diameter of the orbit. We know the greatest angular distance between the stars; we have then the distance of the stars from the earth.

Report of the Committee on Underground Temperature, by Prof. Everett, D.C.L.

The intended boring at the bottom of Rosebridge Colliery has not been executed, recent occurrences in a neighbouring pit having given the manager reason to fear an irruption of water in the event of such a boring being made. Careful observations of temperature have been taken by the engineers of the Alpine tunnel under Mont Frejus (commonly called the Mont Cenis tunnel). The highest temperature in the rocks excavated was found directly under the crest of the mountain, which is quite a mile overhead. The temperature was 85·1° Fahr., the mean annual temperature of the crest over it being estimated, from comparison with observed temperatures at both higher and lower levels (San Theodule and Turin), at 27·3° Fahr. Assuming this estimate to be correct, the increase of temperature downwards is at the rate of 1° in 93 feet, which, by applying a conjectural correction for the convexity of the surface, is reduced to about 1° in 81 feet as the corresponding rate under a level surface. This is about the rate at Dukenfield Colliery, and is much slower than the average rate observed elsewhere. The rocks are extremely uniform, highly metamorphosed, and inclined at a steep angle. They contain silica as a very large ingredient. They are not faulted to any extent, and are very free from water. It is proposed to sink two bores, to the depth of from 50 to 100 feet, at the summit, and another point of the surface over the tunnel, with the view of removing the uncertainty which at present exists as to the surface-temperature. Mr. G. J. Symons has repeated his observations at every fiftieth foot of depth in the water of the Kentish Town well, between the depths of 350 and 1,100 feet, the surface of the water being at the depth of about 210 feet. The observations which have been repeated are thus completely free from the disturbing effect of seasonal changes. The results obtained agree closely with those previously found, and show between these depths a rate of 1° in 54 feet, which, from the estimated mean temperature of the surface of the ground, appears to be also very approximately the mean rate for the whole 1,100 feet. The soil, from 325 to 910 feet of depth, consists mainly of chalk and marl, and shows a mean rate of 1° in 56 feet. From 910 to 1,100 feet, it consists of sandy marl, sand, and clay, and shows a mean increase of 1° in 54 feet. The former of these is in remarkably close agreement with very trustworthy determinations made by Walferden from observations in the chalk of the Paris basin. These are as follows:—Puits de Grenelle, Paris, depth, 400 metres; rate, 1° F. in 56·9 feet. Well at Military School, Paris, depth, 173 metres; rate, 1° F. in 56·2 feet. Well at St. André, 50 miles west of Paris, depth, 263 metres; rate, 1° F. in 56·4 feet. General Helmersen, of the Mining College, St. Petersburg, informs the secretary that, in sinking a well to the depth of 540 feet at Yakoutsk in Siberia, the soil was found to be frozen, probably to the depth of 700 feet. The rate of increase from 100 to 540 feet was 1° F. in 52 feet. A new pattern of thermometer has recently been constructed for the committee, which promises to be of great service. It is a maximum thermometer on Negretti's principle, adapted to be used in a vertical position with the bulb at the top. The contraction in the neck prevents mercury from passing into the stem when the instrument receives moderate concussions. Before taking a reading, the instrument must be gently inclined so as to allow all the mercury in the stem to run together into one column near the neck. On restoring the thermometer to the erect position, the united column will flow to the other end of the tube (that is, the end furthest from the bulb), and it is from this end that the gradations begin. It is set for a fresh observation by holding it in the inverted position, and tapping it on the palm of the hand. This instrument, like that heretofore used by the committee, is protected against pressure by an outer case of glass, hermetically sealed.

SECTION G.

At the opening of this Section on Monday, after disposing of Mr. Symons' Report of the Rainfall Committee, a paper *On a New Form of Steam Blast*, was communicated by Mr. W. Siemens, F.R.S. The new blast is employed for the movement of air in the pneumatic tubes connected with the central telegraph station in London. It is said to cost only 40*l.*, and will do the same work as an engine which costs 2,000*l.*

Mr. Stevenson then read a paper describing what he termed a *Thermometer of Translation.* It consists of an expansible body, with needle point at its upper end, and when expanded by the sun is fixed at its upper end, by a needle point catching into fine teeth cut in a sheet of glass or other material of small expansibility pressed below. The end being fixed, the contraction raises the centre of gravity at the bar. In this way the daily march or creep of the bar chronicles the changes of temperature.

Mr. Michael Scott, in a paper *On Improved Ships of War*, proposed to construct a ship of war, which should combine cruising and fighting qualities, by adopting the turret system for the guns, and having the ship so designed that the free board could be reduced by sinking her deep in the water through the filling of certain cisterns. The masts were to be of telescopic construction.

Captain Jenkin, C.B., said this was a subject of grave importance to the country. He thought, however, it would be necessary before giving an opinion on this paper, that they should be able to understand what, in the proposed ship, was intended to be below the water. All he (the speaker) could see was what was to be above the water, and consequently he could not give an opinion in a professional point of view on the plans produced. While Mr. Scott was entitled to their thanks for what he had produced, he thought it would be necessary for him to bring forward models of the ships he proposed to construct.

A paper *On an Apparatus for Working Torpedoes* was read by Mr. Philip Braham. The author proposed to propel or "shoot" torpedoes against the enemy's ship by means of compressed air, and under the surface of the water.

On Tuesday, the reports on the treatment and utilisation of sewage read in the Chemical Section on Monday having been submitted, a paper on *The Carbon Closet System* was read by Mr. E. C. C. Stanford, F.C.S. In the most populous places the carbon system, he held, was the most practicable, the most healthful, and the most profitable means that could be used in getting rid of the sewage; and he thought that the system of the future must be some modification of the dry system such as that which he had brought before the section. An interesting discussion followed the reading of this paper.

The committee appointed to consider the various plans proposed for legislating on the subject of Steam-boiler Explosions, with a view to their prevention, presented an interim report, in which they stated that the Parliamentary report having been so recently published, there had not been time for its due consideration, or for the committee to meet and confer thereon, and they had postponed entering into the subject on the present occasion.

Mr. Lavington E. Fletcher, C.E., in a paper on *Steam-boiler Legislation*, stated that the Parliamentary Committee had arrived at the three following conclusions, viz.:—(1) That the majority of explosions arise from negligence, either as regards original construction, inattention of users or their servants, neglect of proper repairs, and absence of proper and necessary fittings; (2) that on the occurrence of explosions, a complete investigation of the cause of the catastrophe should be promoted by the appointment of a scientific assessor to assist the coroner; and (3) that reports of each investigation should be presented to Parliament. These three conclusions, it was considered, formed a foundation from which a superstructure would spring in course of time which must eradicate steam-boiler explosions. What the precise character of that superstructure should be is a question on which opinions may differ. Some—among whom are the Parliamentary Committee as already explained—prefer a system of pains and penalties to be inflicted on the steam user in the event of his allowing his boiler to give rise to an explosion. Others prefer a system of direct prevention by the enforcement of inspection on the following general basis:—They would recommend a national system of periodical inspection enforced but not administered by the Government, that administration being committed to the steam users themselves, with a due infusion of *ex officio* representatives of the public. For this purpose they propose that steam users should be aggregated into as many district corporations as might be found desirable, boards of control, empowered to carry out the inspections, and levy such rates upon the steam users as might be necessary for the conduct of the service, being appointed by the popular election of the steam users in each district, the different boards being affiliated by means of an annual conference, in order to promote the harmonious working of the whole system. Its advocates consider that in this way a system of national inspection might be mildly, but, at the same time, firmly administered, and that it would then not only prevent the majority of steam boiler explosions, but prove of great assistance to steam users in the management of their boilers. That it would be the means of disseminating much valuable information. That it would promote improvements. That it would raise the standard of boiler engineering, and prove a national gain. It frequently happened, the paper went on to say, that on the occurrence of disastrous explosions, boiler owners were quite unable to compensate those who had been injured. Such was the case last year at Liverpool, where an explosion occurred at a small iron-foundry, in October, killing four persons, laying the foundry in ruins, smashing in some of the surrounding dwelling-houses, and spreading a vast amount of devastation all round. The owners of the boiler, which had been picked up second-hand, and was a little worn-out thing, were two working men, who but a short time before the explosion had been acting as journeymen. They were possessed of little or no capital, and were rendered penniless by the disaster. Another very similar case, though much more serious, occurred at Bingley in June 1869, where as many as fifteen persons were killed, and thirty-one others severely injured by the explosion of a boiler at a bobbin turnery. In this case the user of the boiler was only a tenant, and, judging from the ruined appearance of the premises after the explosion, any attempt to gain compensation for the loss of fifteen lives and thirty-one cases of serious personal injury would be absolutely futile. The plan of imposing a fixed minimum penalty would tend somewhat to meet this difficulty, as the surplus of one would correct the deficit of another, and in this way a compensation fund might be established for the benefit of the sufferers. This definite minimum penalty would tend to meet the present tendency of boiler owners to seek to purchase indemnities from insurance companies in the event of explosions, rather than competent inspection to prevent these catastrophes, since, if the penalty were made sufficiently high, it would pay an insurance company as well to make inspections and prevent explosions, as to adopt comparatively little inspection, permit occasional if not frequent explosions, and pay compensation.

A short discussion took place, in which it was argued that increased security for the proper inspection and manufacture of boilers should be obtained.

The last paper read in this Section was *On the Rainfall of Scotland*, and contributed by Mr. Buchan. The paper was illustrated by a map of Scotland, showing the average annual rainfall of about 200 places, many of the averages being deduced from observations carried on through a long series of years. The map brought out the large rainfall in the west as compared with the east, a difference which was strongly marked even in the group of the Orkney Islands. The average rainfall in the west, at stations removed from the influence of hills, was from thirty-six to about forty inches; but on the east coast, in similar situations, the rainfall was as low as from twenty-four to twenty-eight inches. In casting the eye towards the watershed of the country running north and south, it was seen that in ascending towards it from the west, there occurred a rapid, but by no means uniform, increase; and in descending from it towards the east, a rapid, but by no means uniform, decrease. The largest rain falls occur almost wholly among the hills forming the watershed north of the Forth and Clyde. The places characterised by the heaviest rainfall are, so far as observation has yet enabled us to determine, the following:—Glencoe, immediately under Rest-and-be-Thankful, 128 inches annually; Ardlin, head of Loch Lomond, 115 inches; Bridge of Orchy, 110 inches; Tyndrum, 104 inches; Glen Quoich, in the south-west of Invernesshire, 102 inches; and Portree, Skye, 101 inches. At no great distance from several of these places the rainfall is by no means excessive, thus pointing out an enormous difference of climate between places not far apart. Along the watershed of that part of Scotland which lies south of the Forth and Clyde, no such excessive rainfall occurs, the highest hitherto observed being only 71 inches, Ettrick Pen Top, 2,268 feet high. This diminished rainfall in the south as compared with places similarly situated further north is doubtless due to the mountains of Ireland to the south-west, which partially drain the rain-bringing winds of their moisture before they arrive at these parts of Great Britain. The distribution of the rainfall is very instructive in many districts, as in the valley of the Forth, from the head of Loch Katrine to North Berwick, where the amount varies from ninety-one to twenty-four inches; in Clydesdale, where the quantity is greatest at the head and foot of the valley respectively, being considerably less at intermediate places; and along Loch Linnhe and through the Caledonian Valley, where the variations of the rainfall were excessive. In all these districts, as well as elsewhere, many cases might be referred to, showing that the amount of the rainfall is very far from being determined by mere height. In truth, it is to local considerations we must chiefly look for an explanation of the mode in which rain is distributed over any district; and hence, in estimating the rainfall, particularly in hilly districts, no dogmatic rule can be laid down which can approximate in accuracy the result arrived at by one skilled in such matters and who is at the same time well acquainted with the district. If those districts were shaded off in which the rainfall did not exceed 30 in. annually, the great grain-producing district of Scotland would be indicated; and it was interesting to note that in those districts which produced the best wheat the rainfall was lower than elsewhere, being in many places as low as 24 in. There are about fifty places at which observations have been made for periods varying from twenty to forty-five years. On comparing the average of the three driest years at each of these places with its average, the amount of the deficiency is found to vary exceedingly, being as much as one-third in some places and as little as one-ninth in others.

Mr. Bateman expressed his great satisfaction that Mr. Buchan had stuck to facts instead of theorising. He went on to say that the correction given for the three dry years was just as fallacious as the correction for altitude. A proposed rule had been laid down of an increase in the rainfall of one and a half per cent. for each 100 feet of elevation, but subsequently that one and a half had been changed to two and a half. Mr. Bateman said that the formula for the three dry years was that for the height. In point of fact it was impossible to lay down any rule that would give accurate results.

Mr. Symons drew attention to the fact that the ratio of the three dry years depended very much on the length of period involved, and showed that the epoch of dry years in the instances quoted varied almost precisely with the length of those averages.

Mr. Bateman and Mr. Symons spoke strongly in favour of the work performed by Mr. Buchan, and of the excellent operations of the Scottish Meteorological Society.

Mr. Milne Home made a few appropriate remarks in reply.

MAXIMUM VELOCITY OF METEORIC STONES REACHING THE SURFACE OF THE EARTH

IN Prof. Nordenskjöld's account of the Aerolitic Shower which took place near Hessle, in Sweden, on the 1st of January, 1869, he mentions, as a remarkable fact, that stones weighing two pounds, which struck the ice of the Larsta-Viken, failed to penetrate, making holes only three or four inches deep in the ice and rebounding. (Vide the *Academy*, Dec. 15, 1870.)

The small velocity retained by these stones at the time of striking the earth is, doubtless, owing to the resistance of the air, and, consequently, is not an indication of the velocity which they had upon entering the atmosphere.

Stones thus penetrating the atmosphere from interplanetary space, would be moving in a resisting medium under the joint influence of their original velocity of translation and the constant action of terrestrial gravity. In the case of small masses, the resistance of the medium would very speedily produce retarded motion; and before traversing twenty or thirty miles of air, they would probably move with a velocity approximating uniformity, and under the action of gravity alone. In other words, they would gradually lose their original velocity of translation, and, descending, nearly or quite vertically, under the action of gravity, would ultimately attain a maximum velocity under the opposing influences of the resisting and accelerating forces, and then descend to the earth with this uniform velocity.

Thus, for example, a rifle bullet shot obliquely into deep water, would very soon lose the horizontal component of its velocity, while the vertical motion would be so rapidly retarded that, at a comparatively short distance below the surface of the water, it would begin to descend vertically with the very moderate uniform motion resulting from the resistance of the liquid and the constant action of gravity.

In like manner, no matter how great the velocity with which a meteoric stone enters the atmosphere, the enormous resistance which it encounters must operate ultimately to produce a similar result, although, in some cases of oblique incidence, the horizontal component of velocity is not entirely lost before reaching the earth.

It is well known that this maximum or limiting velocity of a falling body is attained when the required velocity is such that the resistance is at each instant equal to the weight of the moving body. In the case of small masses moving in the air, it may be shown that this velocity is quite moderate.

The principles of dynamics furnish the means of determining the resistance of a given body moving in a medium of given density when the size of the body and its velocity are known.

Let A = area of cross-section of body at right angles to direction of motion.
D = weight of unit volume of medium (air).
v = velocity of moving body (meteoric stone).
g = acceleration by gravity in a unit of time.
k = a constant co-efficient, deduced from experiment, depending upon the shape of the moving body.

Then we have,

$$\text{Resistance} = k \times A \times D \times \frac{v^2}{2g}$$

Hence, by the conditions under which, as above given, v becomes a maximum, if w = weight of the moving body or stone, we have,

$$k \times A \times D \times \frac{v^2}{2g} = w \therefore v = \sqrt{\frac{2g \times w}{k \times A \times D}} \qquad (a)$$

Applying this formula (a) to the case of a meteoric stone weighing two pounds moving in the air:—let us assume it to be a cubical mass, having a specific gravity of 3 in relation to water as unity. Then its volume = 18·482 cubic inches, and the area of one of its faces = 6·9903 square inches = 0·048544 square feet. Hence, assuming the resistance to act at right angles to the face of the cube, and taking the pound and foot as units, we have—

A = 0·048544 square feet.
D = 0·0807288 pounds = weight of cubic foot of air at 0° C.
w = 2 " = " " stone.
g = 32·1928 feet per second.
v = required maximum velocity in feet per second.